REMARKS

Summary of Amendments

Independent claims 2 and 3 have been amended to include, respectively, the limitations from claims 7 and 8, while claim 6 has been has been amended to include the limitations from claim 9.

Claims 1 and 7-9 have been canceled. As noted in Applicant's RCE-accompanying reply of February 18, 2008, claim 5 was canceled in Applicant's October 10, 2007 reply to the then-previous (June 11, 2007) action by the Office. Nevertheless, on the Office Action Summary page, claims 1-9 are listed as pending, with claim 5 being listed as withdrawn. It is respectfully submitted that claims 1-4 and 6-9 should have been listed as the pending claims, and no claims listed as withdrawn.

Now, claims 2-4 and 6 are pending before the Examiner.

Claim Objections

Claim 1 was objected to for a seeming informality. In abbreviated form, the objected-to phrase read "implanting *X* into, so that *Y* will be contained in, *Z*." It is respectfully submitted that this phrase actually was grammatically correct. Nevertheless, by the present amendment, claim 1 has been canceled, rendering the objection moot.

Claim Rejections – 35 U.S.C. § 103

Claims 1-4 and 6-9: *Zaitsev* (in view of routine skill in art)

Claims 1-4 and 6-9 were rejected under 35 U.S.C. § 103(a) as being unpatentable over *Optical Properties of Diamond: A Data Handbook* by A. M. Zaitsev, in view of alleged routine skill in the art.

Claims 7-9 have been canceled. With regard to claims 1-4 and 6, the rejections are essentially a verbatim repetition of those made in the action of October 18, 2008, which was made final. The only difference is that the resistivity limitation added into claims 1-3 by Applicant's February 18, 2008 amendment has been incorporated *mutatis mutandis* into the restatement of the rejections.

Although the Office's letter laying out its rejections is lengthy, the Office bases the rejection on only a single ground, stated repeatedly (no fewer than eight times), namely:

> However[, in light of the] Zaitsev disclosure[,] for given conditions of the claimed invention, the claim[ed] range[s are] considered to be an obvious matter of finding an optimum workable range for some chosen design requirement utilizing [the] Zaitsev method.
>
> Note that it has been held that where the general conditions of a claim are disclosed in the prior art, discovering the optimum or workable ranges involves routine skill in the art. . . .
>
> Any difference [between] the claimed invention and the prior art may be expected to result in some differences in properties. The issue is whether the properties differ to such an extent that the difference is really unexpected.

(The quotation above is edited, as indicated by the square brackets, for clarity as best understood by Applicant's undersigned representative.)

Applicant's undersigned representative notes that the Examiner is rejecting all of the claims as if they were product claims; they are not—only claim 6 recites a product, semiconductor diamond characterized by special properties according to the present invention.

Hence, for the Office to base its rejection on the ground that "the claimed ranges are . . . an obvious matter of finding an optimum workable range" is to reject subject matter directed **to properties of a product, but not to a method of manufacturing a product**.

The Office is courtesouly admonished to reconsider claims 1-4 as **method claims**. In making its lone ground of rejection, the Office maintains, as quoted above, that it has found in *Zaitsev* "given conditions of the claimed invention." On the contrary, it is respectfully submitted that the Office has not found or pointed out in *Zaitsev*, or otherwise presented any *prima facie* evidence whatsoever, of the "general conditions of" Applicant's pending claims **as a method**.

In particular, it is respectfully submitted that the Office has yet to make a *prima facie* case of any obviousness to the steps *per se* in

> (claim 2) A method of manufacturing *n*-type semiconductor diamond, comprising:
>
> a step of producing diamond incorporating *Li* and *N* by implanting into single-crystal Type IIa or undoped epitaxial diamond essentially not containing impurities *Li* ions at a dose of at least 3.0×10^{15} cm^{-2}, and *N* ions at a dose such that the *Li* and *N* sum-total dose is at least 7.0×10^{15} cm^{-2}, and so that ion-implantation depths at which the post-implantation *Li* and *N* concentrations each are at least 1600 ppm will overlap; and

> a step of annealing said diamond incorporating *Li* and *N* at a temperature in the range of from 800°C to less than 1800°C, under high-pressure conditions of at least 3 GPa;
>
> whereby said diamond has a sheet resistance of not greater than $1.4 \times 10^4\ \Omega/\square$

And the Office has yet to make a *prima facie* case of any obviousness to the steps *per se* in

> (claim 3) A method of manufacturing *n*-type semiconductor diamond in which *Li* and *N* ions are implanted into Type IIa or undoped epitaxial single-crystal diamond, the *n*-type semiconductor-diamond manufacturing method comprising:
>
> a step of implanting the Li ions at a dose of at least 3.0×10^{15} cm^{-2}, and the N ions at a dose such that the *Li* and *N* sum-total dose is at least 7.0×10^{15} cm^{-2}, and so that ion-implantation depths at which the post-implantation *Li* and *N* concentrations each are at least 1600 ppm will overlap; and
>
> a step of annealing the post-implantation diamond at a temperature in the range of from 800°C to less than 1800°C, under high-pressure conditions of at least 3 GPa;
>
> whereby said diamond has a sheet resistance of not greater than $1.4 \times 10^4\ \Omega/\square$.

Applicant's inventive method involves very specific steps that are the result of discoveries described on pages 10 and 11 of the specification. In particular, as lines 6-17 on page 10 explain,

> *Li* and *N* readily combine with each other, as is the case with Li_3N (lithium nitride) existing as a stable nitrogen compound of *Li*. The inventors investigated the practical application of such qualities of *Li* and *N* to the *n*-type doping of diamond by the ion implantation method.
>
> What they discovered as a result is that with single-crystal diamond, if *Li* ions alone are implanted into an *N*-incorporating single-crystal diamond so that it incorporates, from the surface of the crystal to the same depth, 10 ppm or more of each of *Li* and *N*, or else *Li* and *N* ions are implanted into a single-crystal diamond essentially not containing impurities, then as the annealing process is taking place, sooner than *Li* associates with vacancies, *Li* and *N* pairing occurs, and the *Li*–*N* pairs do not associate with vacancies but instead become electrically activated shallow donors.

And furthermore, lines 11-17 on page 11 explain—as quoted in Applicant's February 18, 2008 reply with regard to the subject matter of claim 4 in particular—

> The inventors discovered that due to ion implantation, an atomic-level phenomenon in which implanted ions lose their energy while colliding with carbon atoms within the diamond crystal occurs at identical times

> with *Li* and with *N*, and that the supplying of electrons by the electron beam to the crystal surface of the single-crystal diamond on which ion implantation is carried out makes it so that *Li* and *N* distribute in locations within the single-crystal diamond in which pairing is likely to occur.

Zaitsev nowhere teaches or even suggests discoveries as quoted above from the present specification. And as argued in Applicant's February 18, 2008 reply,

> the methods of the present invention bring about *Li* and *N* pairing, such that the *Li*–*N* pairs do not associate with vacancies but instead become electrically activated shallow donors. This unexpected pairing of *Li* and *N* dopant ions leads to the low sheet resistance that is a distinguishing feature of *n*-type diamond according the present invention.

Zaitsev nowhere teaches or even suggests steps in an *n*-type diamond manufacturing method such as would lead to pairing of *Li* and *N* dopant ions.

In particular, *Zaitsev* is silent as to:

- a high *Li* implantation dose not found in the reference, which mentions 10^{15} cm^{-2}, of at least 3.0×10^{15} cm^{-2},
- an at least 1600 ppm concentration of overlapping *Li* and *N* that is higher than the concentration (568 ppm) noted in the reference, and
- the implantation damage only being repairable—since the sum-total implantation dose is a high 7.0×10^{15} cm^{-2} or greater—by the high-pressure/temperature annealing (step of heat-treating under high-pressure conditions of at least 3 GPa at a temperature in the range of from 800°C to less than 1800°C) recited in the claims,

whereby low sheet resistance, i.e., not greater than 1.4×10^4 Ω/□, *n*-type diamond can be produced. Hence, claims 2 and 3 should be held to be patentable over *Zaitsev* in combination with any routine skill in the art.

In making its February 18, 2008 RCE, Applicant has paid the Office's fees for continued examination. Accordingly, in the interest of advancing the prosecution of this case, the Office is courteously requested to give Applicant its due, and reconsider the merits of the pending claims **as a method**.

Further, it is respectfully submitted that the lack of a *prima facie* case of obviousness of the method claims will in turn underscore the non-obviousness of claim 6. The amendments to claim 6 now mean that the Office would have to show how a skilled artisan would arrive at the present invention's producing Type IIa diamond having a sheet resistance of not greater than 1.4×10^4 Ω/□.

Conclusion

Applicant courteously urges that this application is in condition for allowance. Reconsideration and withdrawal of the rejections is requested. Favorable action by the Examiner at an early date is solicited.

Respectfully submitted,

June 27, 2008

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